Mt Hope Bay and Taunton River

Background on Dissolved Oxygen

Dissolved Oxygen (DO) in Mt Hope Bay and the Taunton River has been measured in numerous studies that each have limited extents of time and space. The most recent measurements are from two anchored buoys at a Cole River station and [redacted] station, which were deployed by Mass DEP in September 2016. Measurements of concentration and % saturation of DO are recorded at 15 minute intervals at two depths; near the water surface and near the bottom of the bay. These buoys will be maintained for the foreseeable future to provide continuous monitoring data for the Mt Hope Bay.

The DO data can be compared to critical concentrations that are under consideration as acute or chronic criteria. Because the data are continuous, the frequency and duration of exceedances of various thresholds can be determined. To summarize the data available for this report, seven DO thresholds were identified and exceedances were quantified in terms of the number of distinct exceedances in the period of record (September 1 – November 18, 2016), the length of the exceedances in hours, and other statistics of frequency and duration.

There were few DO exceedances at the surface at the Cole River buoy (Table 1). All exceedances were in September, including each day from September 2 – 5. There were no exceedance less than 5 mg/L. The minimum % saturation for the period of record was 70.1%, associated with 4.91 mg/L DO in early September. At the surface, DO patterns over time were more variable in September than in later months, with peaks rising considerably above background levels on a daily basis (Figure 1). The largest daily flux was 9 mg/L, ranging from 7 – 16 mg/L. There are several values >12 mg/L in September. These values are very high and warrant scrutiny relative to probe calibration records.

There were several DO exceedances at the bottom at the Cole River buoy (Table 1), all occurring before October 15 in the period of record. The minimum % saturation was 17.6% associated with 1.28 mg/L in early September. DO concentrations were <5 mg/L (a potential chronic threshold) for one in five days, including whole days and consecutive days. On eight separate occurrences (10% of the days), DO was <2.9 mg/L (a potential acute threshold). At the bottom, variability was greatest until mid-October, when there was a gap in the record (Figure 2). Fluctuation was not on a daily basis, but showed 4-6 day depressions in DO at 10-15 day intervals. Daily fluctuation was also apparent, but the variation by day was usually less than 3 mg/L, while the depressions were closer to 5 mg/L. These patterns might have been related to temperature or precipitation patterns, though temperature and precipitation data were not immediately available for correlation. Similar DO patterns were observed when DO was plotted as percent saturation.

Table 1. Tabulation of DO exceedance statistics for the Cole River continuous monitoring buoy for the period September 1 — November 18, 2016.

	<1.4 mg/L	<2.3 mg/L	<2.9 mg/L	<3.0 mg/L	< 4.8 mg/L	< 5.0 mg/L	<6.0 mg/L
Surface							
Occurrences (days)	0	0	0	0	0	0	7
% of total days	0	0	0	0	0	0	8.9
Max duration (hrs)	0	0	0	0	0	0	13
% of total hours	0	0	0	0	0	0	1.7
Consecutive days (1)	0	0	0	0	0	0	4
Consecutive days (2)	0	0	0	0	0	0	1
Bottom							
Occurrences (days)	1	3	8	8	14	16	28
% of total days	1.3	3.8	10.1	10.1	17.7	20.3	35.4
Max duration (hrs)	1	5	18	20	24	24	24
% of total hours	0.1	0.5	3.3	3.8	8.0	9.1	19.4
Consecutive days (1)	1	1	3	3	5	5	8
Consecutive days (2)	0	0	1	1	3	3	4
Definitions							
Occurrences (days)	Number of days in the period in which any exceedance was recorded						
% of total days	Percentage of days in which any exceedance was recorded						
Max duration (hrs)	The maximum duration of all exceedances in hours per day						
% of total hours	The percentage of total hours in which an exceedance was recorded						
Consecutive days (1)	The maximum consecutive days with any exceedance						
Consecutive days (2)	The maximum consecutive days with exceedances lasting > 12 hrs						

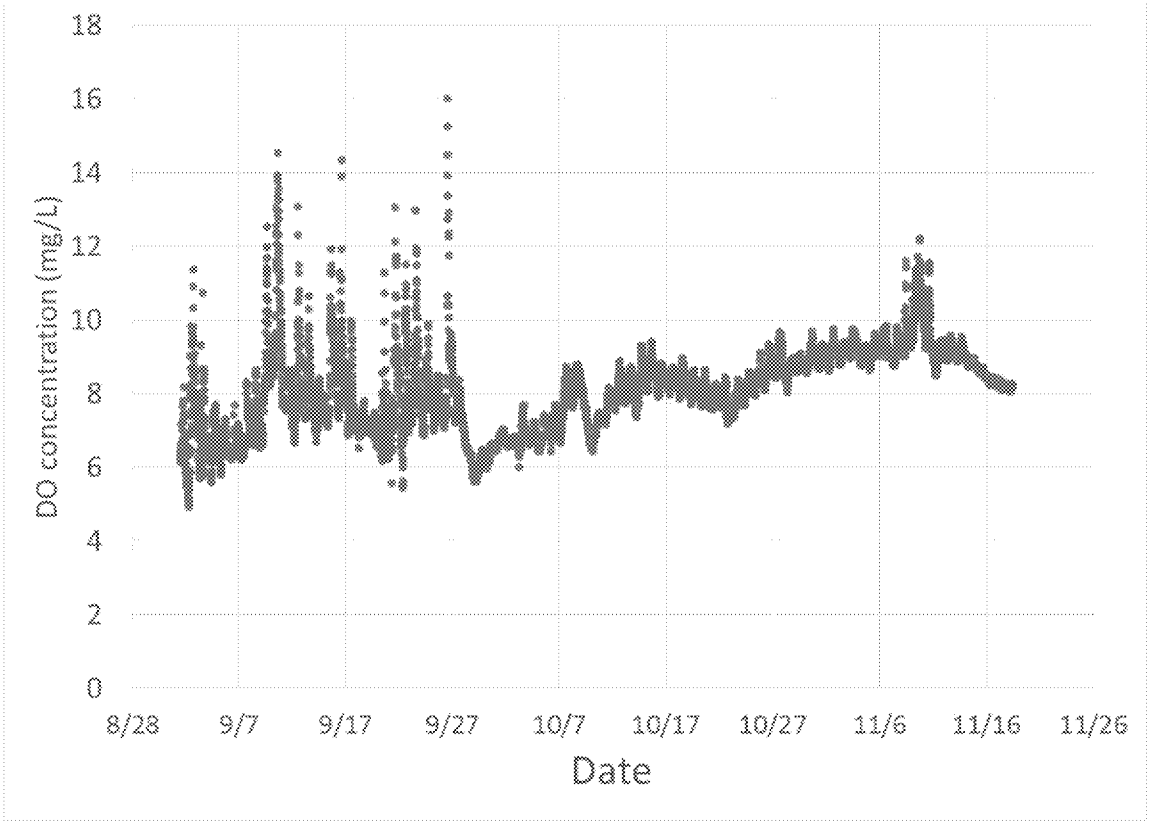

Figure 1. Surface DO concentration at the Coles River buoy by date in 2016.

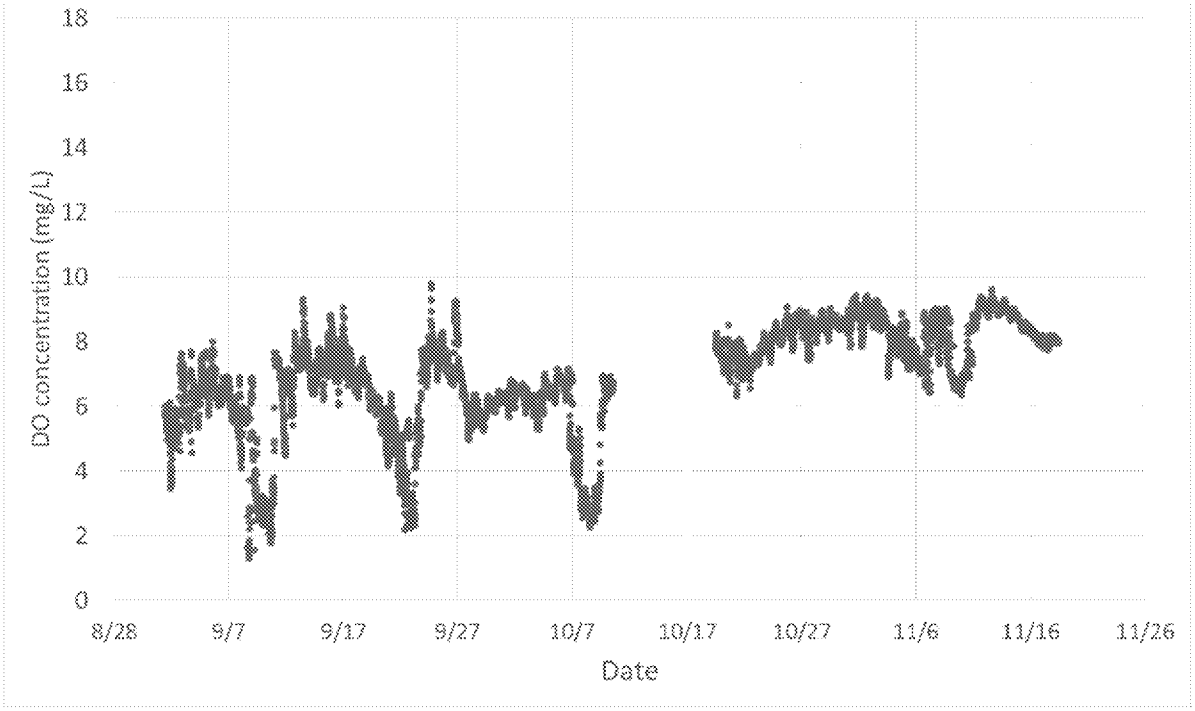

Figure 2. Bottom DO concentration at the Coles River buoy by date in 2016.

The Southeastern Regional Planning and Economic Development District (SRPEDD), in collaboration with the University of Massachusetts' School of Marine Science and Technology (SMAST), initiated in the summer of 2004 a water quality monitoring program in Mt. Hope Bay and the Taunton River sub-watersheds consistent with the Massachusetts Estuaries Project (MEP) water quality data requirements (SMAST 2007). Samples were collected from 19 stations 1-2 times per month from June to September for three years. Three samples were collected per station, by depth (surface, mid-column, and bottom). The sites were located in the Taunton River downstream of the Berkley Bridge (6 sites), in the Massachusetts portion of the Mt Hope Bay (6 sites), and in the Rhode Island portion of the Mt Hope Bay (7 sites). During the monitoring period, Brayton Point Plant was operating open cycle, discharging heated water into Mt Hope Bay.

In addition to DO, Secchi depth, temperature, conductivity, salinity, nutrients (TN, TON, NH_4, NOx, DIN, DON, PON, POC, C/N, and PO_4), TSS, chlorophyll-a, sample time, low tide time, and antecedent 24-hour precipitation were recorded. The focus of the data summary was on the minimum DO of all readings per station per month, regardless of sample depth. This was to emphasize the most stressful DO conditions. DO was typically lowest in the bottom sample, though not always.

All samples were collected on the ebb tide, nominally, though collection times were up to 6 hours before low tide and some were up to an hour after low tide. On average, samples were collected 2:45 hours before low tide. Antecedent heavy rain was not common and was never recorded in 2005. In 2004 and 2006, antecedent 24 hr heavy rain occurred in one sample per year. The rain samples had lower average DO compared to samples collected without antecedent heavy rain in the same month. Salinity was lowest in stations 19-21, furthest upstream in the Taunton River. Salinity was only <0.5 ppt ("fresh") in a few samples upstream in the Taunton River in 2006. Salinity readings were typically between 20-30 ppt. In 2004 and 2005, about 75% of the readings were in that range. In 2006, only 60% of the samples were >20 ppt.

Minimum DO concentrations are tabulated in Table 2 and mapped in Figures 3 - 6. There are several minimum monthly values that are below 5 mg/L (a potential chronic threshold) and only three values that are below 2.9 mg/L (a potential acute threshold). The values are variable over location and month. These are minimum values regardless of position in the water column, but probably represent bottom conditions more than surface or mid-column conditions. The lowest DO concentrations were recorded in July of each year.

Table 2. Monthly minimum DO concentrations as recorded in the SMAST data from Mt. Hope Bay and the Taunton River. Concentrations are color coded to emphasize high concentrations in blue tones and low concentrations in red tones. Stations are in the Taunton River (TR), Massachusetts portion of the Mt Hope Bay (MA), or the Rhode Island portion of the Mt Hope Bay ((RI), as noted in the Stations column and in Figures 3-6.

Station	June, '04	July, '04	Aug, '04	June, '05	July, '05	Aug, '05	Sept, '05	June, '06	July, '06	Aug, '06	Sept, '06
MHB-1 (TR)	4.80	5.43	5.52	6.21	5.44		5.13	4.14	5.59	6.06	
MHB-2 (TR)	4.71	5.28	6.19	6.19	5.00	5.11	5.10	5.05	2.95	5.28	8.67
MHB-3 (MA)		5.08	5.73	6.92	5.19	5.72	5.29	6.15	6.16	4.83	8.63
MHB-4 (MA)		5.37	4.72	5.64	5.09	7.17	7.22	8.42	7.42	6.06	8.70
MHB-5 (MA)		4.67	5.05	5.58	4.64	6.97	6.64	5.90	5.35	5.13	7.01
MHB-6 (MA)		5.37	4.88	6.91	5.78	4.69	6.01	6.85	5.83	5.28	8.45
MHB-7 (MA)		7.15	3.40	8.46	7.21	5.28	6.52	7.07	7.35	7.20	7.94
MHB-8 (MA)		4.30	3.83	4.65	2.56	5.67	6.32	5.89	6.36	5.62	8.25
MHB-10 (RI)		6.05	5.95	8.45	7.42	5.43	6.56	7.69	6.21	5.44	8.51
MHB-11 (RI)		3.18	4.63	4.65	4.53	4.45	6.58	6.31	5.69	5.53	7.38
MHB-12 (RI)		4.03	5.91	6.64	3.95	5.83	5.78	8.14	6.41	5.36	7.03
MHB-13 (RI)		6.51	6.66	7.00	5.96	4.09	5.28	6.93	6.74	6.15	8.51
MHB-14 (RI)		6.27	6.04	8.42	0.72	8.2	6.19	7.10	2.14	5.72	8.73
MHB-15 (RI)		6.89	7.32	8.16	6.40	6.33	6.54	10.31	4.25	7.14	9.46
MHB-16 (RI)		6.60	6.20	7.77	5.99	6.89	6.16	7.89	5.27	6.67	9.72
MHB-18 (TR)	4.66	5.03	5.14	5.87	5.66	5.61	4.44	6.57	4.31	5.59	7.76
MHB-19 (TR)	5.42	5.15	4.44	6.14	5.96	5.90	4.70	4.64	4.69	5.80	7.66
MHB-20 (TR)	5.11	5.43	5.38	6.48	6.22	7.18	5.61	4.77	4.88	6.26	8.19
MHB-21 (TR)	4.86	4.77	3.79	6.00	6.14	6.32	4.12	4.84	4.78	6.02	7.79

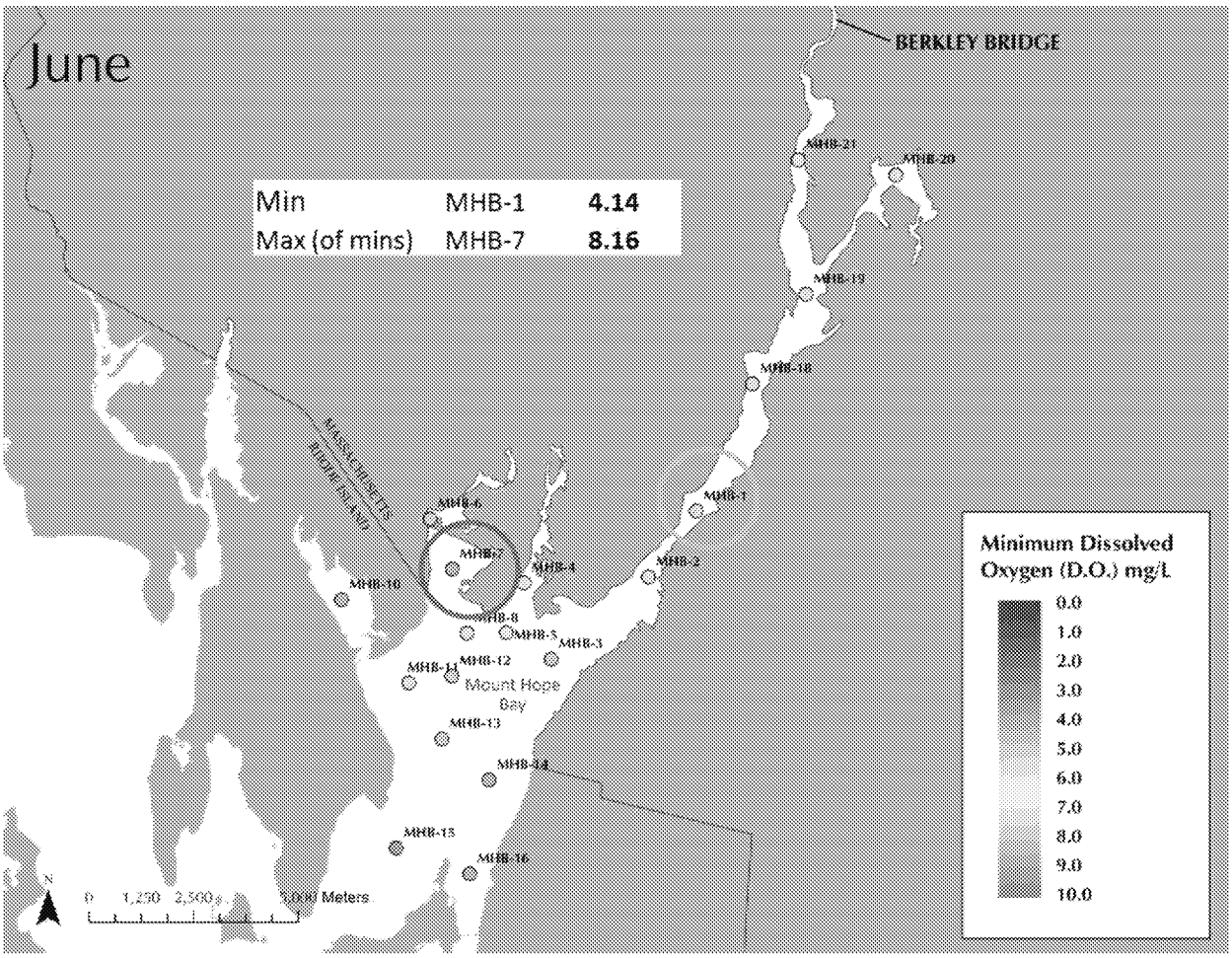

Figure 3. Minimum DO concentrations in June of 2004 – 2006 at locations throughout Mt Hope Bay and the Taunton River, highlighting stations with extreme values.

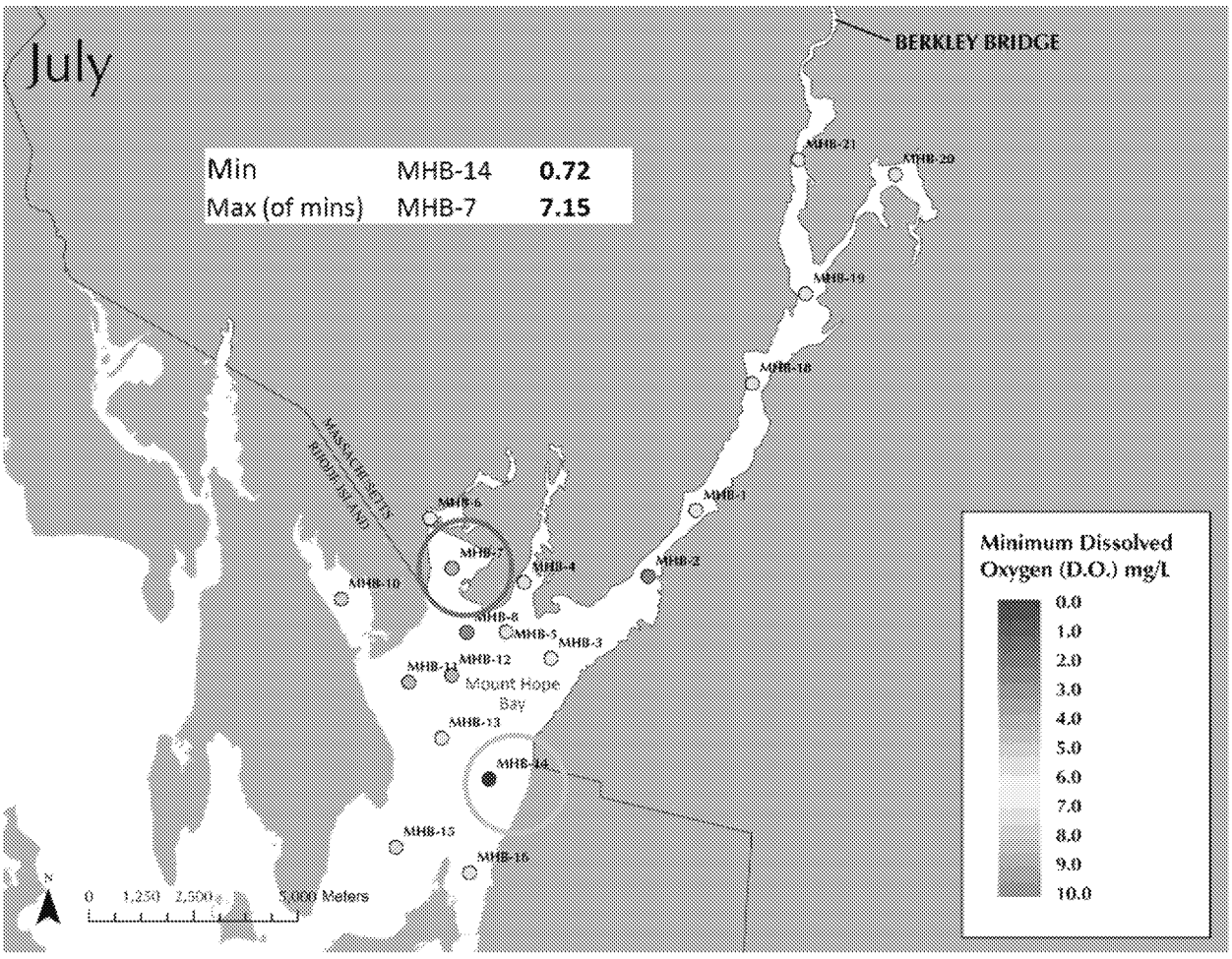

Figure 4. Minimum DO concentrations in July of 2004 – 2006 at locations throughout Mt Hope Bay and the Taunton River, highlighting stations with extreme values.

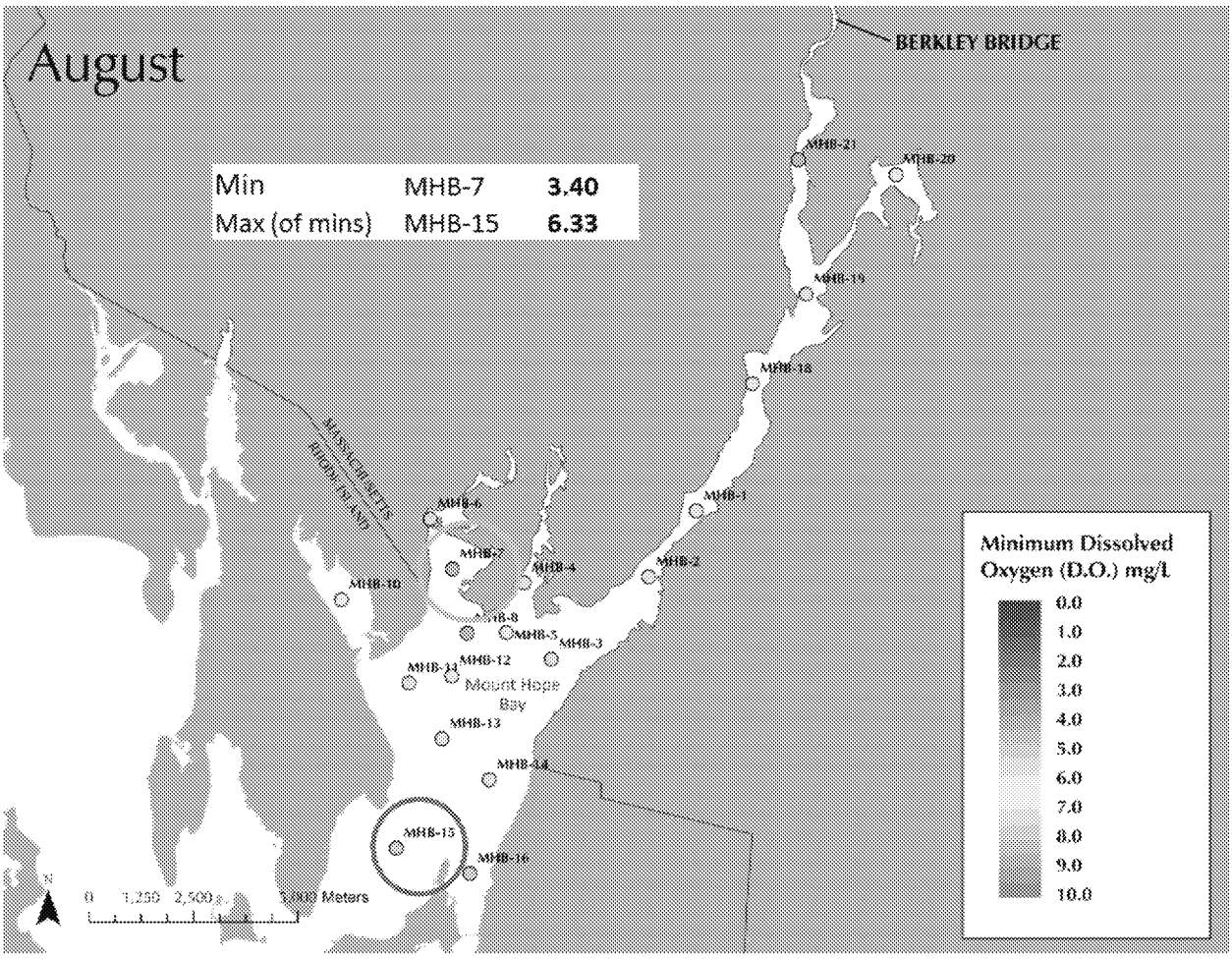

Figure 5. Minimum DO concentrations in August of 2004 – 2006 at locations throughout Mt Hope Bay and the Taunton River, highlighting stations with extreme values.

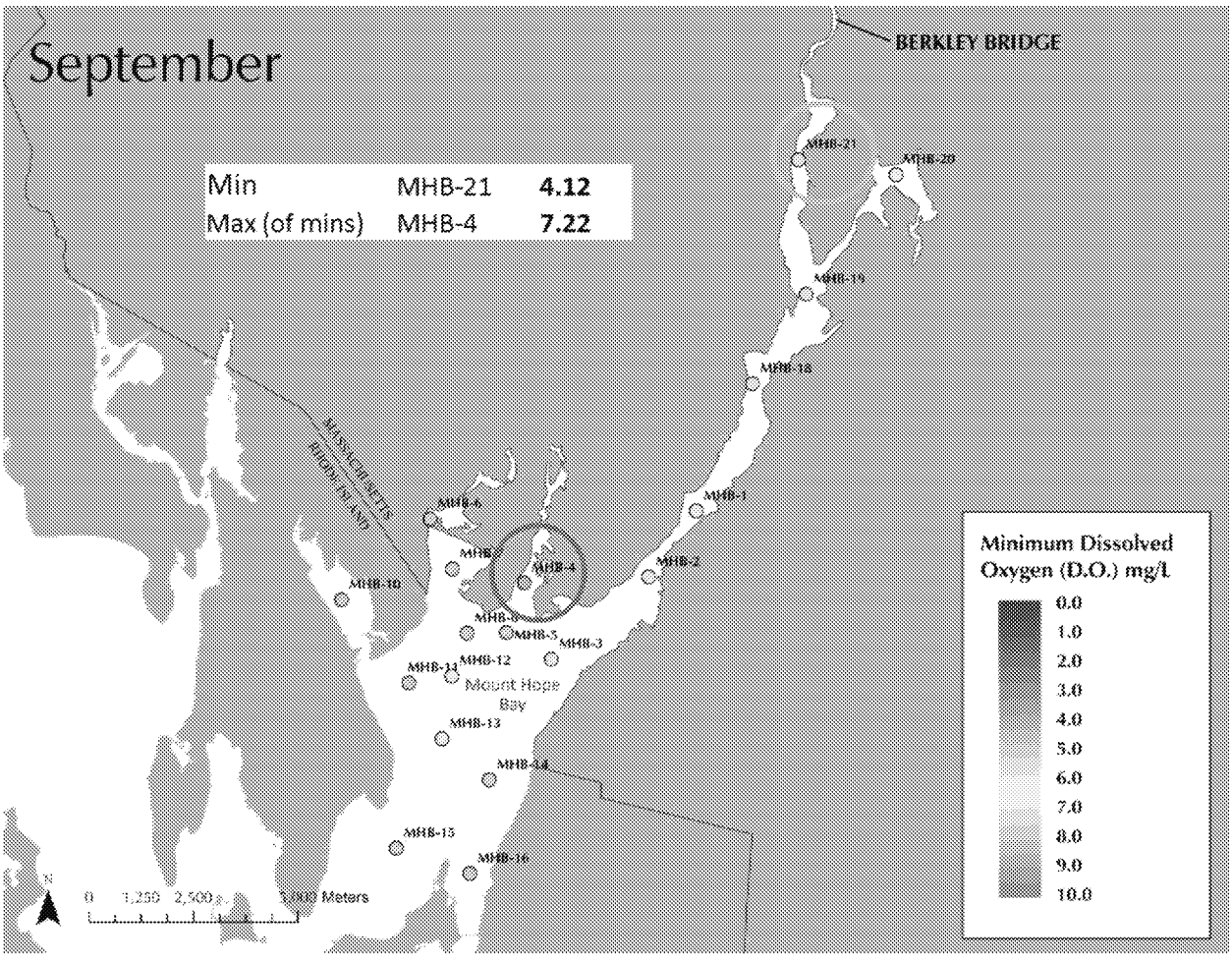

Figure 6. Minimum DO concentrations in September of 2004 – 2006 at locations throughout Mt Hope Bay and the Taunton River, highlighting stations with extreme values.

In a study of hypoxia in Narragansett Bay in 2001 and 2002, it was found that 15% of the bottom area surveyed in the Mt Hope Bay was hypoxic, with DO concentrations < 3 mg/L in August (Deacutis et al. 2006). During the same single day surveys, surface DO concentrations were consistently > 4 mg/L. The hypoxic areas were generally in the embayments of the Lee and Cole Rivers. Depths to pycnoclines were vague in Mt Hope Bay, but <3 m and < 5 m were mentioned for other study areas. Deep holes (<5-10m) in Mt Hope Bay were hypoxic.

For application, consider comments by Heather Stoffel from URI (email)

1. Based on the daily average approach to a criteria: We have seen in our data that daily averages are not representative conditions in areas >3-3.5m deep. Because these area are shallow and light can reach the bottom easily, we see a diel pattern in oxygen (day-night readings can range from 6-0 mg/L). A daily average of these area would make it appear to be better than it actually is. Therefore, if time series information is not available for these areas, then a criteria based on night or early morning condition could be applied to assess the worst possible conditions.

2. Data/assessments: If a duration of time below a certain threshold approach is taken with the state's criteria, then time series data is needed to evaluate or assess an area. It is also beneficial to have an understanding on how the selected criteria will be used in assessments with the different types of monitoring strategies (ie grab/spot sampling, time series, etc). For example, how many spot check readings do you need to list an area as impaired or how long is an area allowed listed as unassessed in these spot check areas before action is needed? If an area is showing signs of a problem through spot checks, but there are no funds for time series monitoring, how can you properly evaluate these areas with the data that is available?

References Cited

SMAST Report. 2007. Summary of Water Quality Monitoring Program for the Mount Hope Bay Embayment System (2004 – 2006). Prepared for the Southeastern Regional Planning and Economic Development District (SRPEDD) and the MA DEP 604(b) Program.

Deacutis, C.F., D. Murray, W. Prell, E. Saarman, and L. Korhun. 2006. Hypoxia in the upper half of Narragansett Bay, RI, during August 2001 and 2002. *Northeastern Naturalist*, *13*(sp4), 173-198.